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Measurement and Reporting Guidelines for Plant Growth Chamber Environment

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16. ABSTRACT

For two decades scientists have been using plant growth chambers to make significant contributions in agricultural research. Much too often, haphazard and incomplete environmental measurements have made it difficult, if not impossible, to gain the full utility of this research. Guidelines were developed initially by members of the North-Central Region Technical Committee on Growth Chamber Use. These guidelines are included on a table. The adoption of these guidelines by researchers and adherence to these suggestions by review editors will improve the quality of environmental research and aid in making comparisons among studies conducted in different laboratories.

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LETTER TO THE EDITOR

Measurement and Reporting Guidelines for Plant Growth Chamber Environment

For two decades scientists have been using plant growth chambers to make significant contributions in agricultural research. Much too often, haphazard and incomplete environmental measurements have made it difficult, if not impossible, to gain the full utility of this research. Concern for completeness and accuracy of these measurements has been the driving force behind an effort to establish a set of guidelines useful in conducting and reporting research in plant growth chambers.

Guidelines were developed initially by members of the North-Central Region Technical Committee on Growth Chamber Use (NCR-101), a committee formed under the Cooperative Regional Research Program of the State Agricultural Experiment Stations and the U.S. Department of Agriculture. They were extensively critiqued, amended, and expanded by the American Society of Horticultural Science Controlled Environments and Growth Chamber Working Group and the American Society of Agricultural Engineers Structures and Environment Committee (SE 303). These guidelines were presented to over 100 participants at a three-day Controlled Environments Working Conference (University of Wisconsin-Madison, March 1979) sponsored by the above groups and the University of Wisconsin. The importance of each environmental parameter and the state-of-the-art measurement techniques were presented by a scientist working primarily in that research area. The proposed guidelines were next presented by a member of the NCR-101 Committee, and several hours of open discussion followed. Based on the detailed discussion, some modifications were made and the guidelines along with the entire proceedings were published in *Controlled Environment Guidelines for Plant Research* (T. W. Tibbitts and T. T. Kozlowski (ed.). 1979. Academic Press, New York.). Since that time, some additional modifications have resulted from critical evaluation by journal editors and peer reviews. These modifications have received the support of the originating committee (March 1982).

These guidelines, presented in Table 1, reflect the current thinking of many scientists, engineers, and manufacturers. They provide recommendations on types of instruments to use for measurement, where and when measurements should be taken, and the format and units that should be used in reporting the environment of each study. These guidelines have incorporated the International System of Units (SI units). It is anticipated that these guidelines will be updated as instrumentation is improved and the need for greater environmental precision is demanded by environmental researchers.

The adoption of these guidelines by researchers and adherence to these suggestions by review editors will improve the quality of environmental research and aid in making comparisons among studies conducted in different laboratories. I strongly urge and encourage their adoption.

Received July 1980

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Table 1—Guidelines for measuring and reporting the environment for plant studies.

Parameter	Typically used unit	Measurements		
		Where to measure	When to measure	What to report
Radiation				
Photosynthetically active radiation (PAR). 400–700 nm with cosine correction.		At top of plant canopy. Obtain avg over plant growing area.	At start and finish of each study and biweekly if studies extend beyond 14 d	Avg over containers at start of study. Decrease or fluctuation from avg over course of the study.
1) Photosynthetic photon flux density (PPFD)	μmol s^{-1} m^{-2}† or μE s^{-1} m^{-2}			
2) Photosynthetic irradiance	W m^{-2}			
Total irradiance. With cosine correction. Indicate wave band.	W m^{-2}	At top of plant canopy in center of growing area.	At start of each study.	Avg over containers and wave band measured.
Spectral distribution. Wave band ($\lambda_1 - \lambda_2$) specified. Measured in ≤ 20 nm band widths. Cosine corrected.		At top of plant canopy in center of growing area.	At start of each study.	Graph or table plus integral ($\lambda_1 - \lambda_2$). Source of radiation and instrument/sensor.
1) Spectral photon flux density	μmol s^{-1} m^{-2} nm^{-1}†			
2) Spectral irradiance	W m^{-2} nm^{-1}			
Illuminance.‡ 380–780 nm with cosine correction	klx	(Same as PAR.)	At start of each study.	Avg over containers.
Temperature				
Air. Shielded and aspirated (≥ 3 m s^{-1}) device.	°C	At top of plant canopy. Obtain avg over plant growing area.	Hourly over the period of the study (continuous measurement advisable).	Avg of hourly avg values for the light and dark periods of the study with range of variation over the growing area.
Soil or liquid.	°C	In center of container.	Hourly during the first 24 hr of the study. Start immediately after watering (monitoring over the course of the study advisable).	Avg of hourly avg values for the light and dark periods for the first day or over entire period of the study if taken. Location of measurement.
Atmospheric moisture				
Shielded and aspirated (≥ 3 m s^{-1}) psychrometer, dew point sensor, or infrared analyzer.	% RH, dewpoint temperature, or g m^{-3}.	At top of plant canopy in center of plant growing area.	Once during each light and dark period, taken at least 1 h after light changes. Monitoring over the course of the study is advisable.	Avg of once daily readings for both light and dark periods with range of diurnal variation over the period of the study (or avg of hourly values if taken).
Air velocity	m s^{-1}	At top of plant canopy. Obtain maximum and minimum readings over plant growing area.	At start and end of studies. Take 10 successive readings at each location and average.	Avg and range of readings over containers at start and end of the study.
Carbon Dioxide	mmol m^{-3}	At top of plant canopy.	Hourly over the period of the study.	Avg of hourly avg readings and range of daily avg readings over the period of the study.
Watering	L	–	At times of additions.	Frequency of watering. Amount of water added per day and/or range in soil moisture content between waterings.
Substrate	–	–	–	Type of soil and amendments. Components of soilless substrate. Container dimensions.
Nutrition	Solid media: mol m^{-3}, or mol kg^{-1} Liquid culture: μ or mmol L^{-1}	–	At times of nutrient additions.	Nutrients added to solid media. Concentration of nutrients in liquid additions and solution culture. Amount and frequency of solution addition and renewal.
pH	pH units	In saturated media, extract from media, or solution of liquid culture.	Start and end of studies in solid media. Daily in liquid culture and before each pH adjustment.	Mode and range during study.
Electrical Conductivity	dS m^{-1}§ (decisiemens per meter)	In saturated media, extract from media, or solution of liquid culture.	Start and end of studies in solid media. Daily in liquid culture.	Avg and range during study.

† The first is preferred because it follows the SI convention. However, since 1 Einstein = 1 mol of photons, the values are equivalent. It is inaccurate to report that "radiation values are xx.x μmol $s^{-1}m^{-2}$," for the same reason that reporting mol kg^{-1} is wrong without associating that value and units with the element (i.e., K was 300 mol kg^{-1}). Thus, "the PFFD was 320 μmol s^{-1} m^{-2}" is correct since it specifically associates a definition (i.e., photons within a certain waveband) with the value and units.

‡ Report with PAR reading *only* for historical comparison.

§ 1 dS m^{-1} = mmho cm^{-1}.